SNOW LOAD DATA for ARIZONA

STRUCTURAL ENGINEERS ASSOCIATION OF ARIZONA

SNOW LOAD DATA FOR ARIZONA

Published By

Structural Engineers Association of Arizona

In Cooperation With

Arizona State University

Mac Elliott

Snow Load Committee Chairman - S.E.A.A.

1973

Second Printing - 1981

SNOW LOAD DATA FOR ARIZONA

Contents

FORWARD TO SECOND PRINTING OF SNOW LOAD DATA FOR ARIZONA. NOVEMBER, 1981

This Report originally advised caution in the use of the tabulated 30 year snow load figures. Caution is still advised. However, nothing has come to the attention of the Committee during the 8 years since the first printing to warrant significant revisions of the tabulated loads. Therefore, tables, charts, and text are left unchanged for this second printing.

It is strongly recommended that snow load records continue to be monitored, and compared with the data in this book. Individual changes should be made where warranted. Also, data from new stations is becoming available. Sometime in the future a thorough review of all the then available information, with subsequent updating and/or expansion of these tables may be advisable.

Perhaps the expanded data base available in the future would permit more formalized statistical projections, along the lines of the Weibull and Log Pearson Type III distributions used in much of the recent snow load work in other areas. However, even with such statistical approaches, considerable judgement will still be necessary in arriving at projected loads for specific sites. Arizona's winter weather is too variable. -- e.g. Weather coming from the Pacific Coast over a highly variable terrain and subject to a high degree of modification on the way, -- A warm State with a rain vs. snow picture extremely spotty and variable from year to year, -- Local conditions varying widely from point to point, -- etc.. Statistics are helpful, but judgement is essential.

The question has been raised as to how the tabulated 30 year loads relate to probable 50 and 100 year loads. In answer, most distributions used for hydrological predictions would show the 50 year recurrent load as about 15% higher than the 30 year load, and the 100 year recurrent load as about 25% greater than the 30 year load. These figures also seem reasonable for snow.

One more question that keeps coming up is how to turn inches of snow into weights on the ground. As stated in the Report, rules of thumb can be misleading. Densities routinely vary between 5% and 50% water. However, certain numbers may be useful as a rough guide in the higher, colder areas, where substantial snow pack remains for much of the winter. December, 10% to 20% water, January, 15% to 25% water, February, 20% to 30% water, March, 30% to 40% water, and April, 35% to 45% water.

Mac Elliott

SNOW LOAD DATA FOR ARIZONA

INTRODUCTION:

For many years a need has existed for a guide to aid in estimation of the weight of snow which might be expected to occur on structures in the Arizona high country. This report is intended to serve as such a guide.

SCOPE:

The report is based on available records of snow depths and water contents. Basic ground and roof snow loads representing probable 30 year maximums are developed, and a detailed listing of these loads is given for various reporting stations around the State.

Also included are recommendations for roof design load modifications due to the following factors: wind removal of roof snow, roof slopes, unbalanced loads, roof valleys, multilevel roofs, roof projections, and ice loads.

SOURCES OF DATA:

Two basic sets of records are available from which maximum snow loads may be estimated. U. S. Soil Conservation Service Snow Surveys and U. S. Weather Bureau records.

Soil Conservation Service (S.C.S.) readings are made twice a month and date back to 1938 at some stations. Measurements are taken for the most part away from populated areas, which somewhat limits their direct applicability to building in these areas. However, the data is extremely valuable due to inclusion of actual measurements of water content in the snow. Depths of snow are also recorded.

Available Weather Bureau (W.B.) records on the other hand list only snow depths, not water content, but do include reporting stations for nearly all of Arizona's inhabited communities. Some records date back to 1895, but longevity as well as completeness of these records varies greatly throughout the State.

Map No. 2 shows the Weather Bureau reporting stations and Map No. 3 the S.C.S. snow courses.

SOURCES OF DATA (Continued)

A third source of information is the report, "Actual Snow Loads in Arizona" by H. M. Elliott. This is a detailed study of the great storm of December 13 - 20, 1967, and lists snow loads in pounds per square foot as well as the snow depths for 111 different reporting stations around the State. As this storm produced the heaviest short period snowfall on record in most areas of the State, the report provides a useful guide in arriving at basic ground load criteria.

See Bibliography at end of this report for additional sources of information.

CONVERSION OF SNOW DEPTHS TO LOADS:

The foregoing data sources were searched to obtain the maximum recorded snow depths or loads at all reporting areas. (See Tables 1 - 5.) The snow depths without loads from the Weather Bureau records, and from a few incomplete Soil Conservation records, then had to be converted into pounds per square foot on the ground.

Any conversion at this time from depths listed on a printed page to maximum weights that existed on the ground years ago is fraught with error. To illustrate the problem, two listings are included for Hawley Lake. They give both the record maximum depth of 91" with a measured weight of 57 p.s.f. for 1967 (12% water), and the record maximum weight of 103 p.s.f. with a depth of only 45" for 1973, (44% water). These weights were not estimates, they were actual S.C.S. measurements. It is apparent that in spite of all the theoretical conversion data available in the literature (from snow depths to p.s.f.), an educated guess is the best we can hope for.

The process used to convert listed snow depths into pounds per square foot at stations without recorded loads was to search S.C.S. and Elliott data for comparable conditions. (S.C.S. and Elliott data contain both snow depths and p.s.f. loads.) Comparing this information with the depth at the station in question, a p.s.f. snow load estimate was made for that station. All listed Weather Bureau maximum p.s.f. data was arrived at in this manner, plus that for a few S.C.S. stations noted with asterisks (*). There is no way of judging accuracies of these weight estimates, but hopefully they are within 30%±

DEVELOPMENT OF BASIC GROUND SNOW LOADS:

Considerable effort was expended in an attempt to group geographical areas into "Snow Zones" so that meaningful snow load-to-elevation relationships could be developed for each zone. For convenience, areas used by the U.S. Weather Bureau in their Statewide reporting service were utilized in this grouping, since each such area has its own weather pattern. See Map No. 1.

Maximum recorded or estimated snow loads were plotted against elevation above sea level for each grouping. See Figs. 1 - 5. Curves were then drawn, generally but not always, through the high side of the plotted points. The final division of the State into five snow load zones provided helpful load-to-elevation curves for Zones I and V, and to a lesser degree for Zones II, III and IV.

The original intent was to use these curve values as Basic Ground Loads, similar to the approach taken in the Oregon and Colorado reports, (See Bibliography Nos. 4 and 5). However, due to the wide scatter of data this approach was finally abandoned. Each site was considered individually and a Basic Ground Load assigned accordingly. See Tables 1 - 5. The curves were used only as aids in arriving at Basic Ground Loads, and no curves have been reproduced with this report for fear of misleading.

This wide data scatter suggests the importance of considering all the pertinent features of an individual site rather than just the elevation. For example, south slopes and exposure to sun are very effective in reducing long term snow buildup. Flagstaff, with its south exposure, had almost no long term buildup during the spring of 1973, while Newman Park, 15 miles south hit 75 p.s.f. and Happy Jack, 35 miles south reached 105 p.s.f. on the ground.

A study of the Statewide storm pattern shows the higher elevations of Zones II, III and IV, "stripping" most of the snow out of winter storms before it reaches Zone I. Snow loads are light in the northeast, "Four Corners" area. (There was no reporting Zone I station above 7,500 feet, but a snow load increase seems possible above this elevation. An estimate of 30 p.s.f. Basic Ground Snow Load at 8,000 feet seems reasonable for Zone I.)

Due to scarcity of data and wide variation of conditions, structures above 8,500 ft. in Zones I and V, and above 10,000 ft. in Zones II, III and IV should have special investigations to determine design snow loads.

DEVELOPMENT OF BASIC GROUND SNOW LOADS (Continued)

Normal roof live loads should govern over snow loads below about 4,500 feet at Zones I and V, and below about 3,000 feet at Zones II, III and IV.

MISCELLANEOUS FACTORS AFFECTING RELIABILITY:

Probably the two factors most adversely affecting reliability have been shortage of data and the necessity of estimating snow weights from Weather Bureau depth records. Unfortunately for the purposes of this report, the populated areas containing most of the building activity do not have records of actual snow weight measurements. To compensate for these shortages, as much nearby data, (S.C.S., W.B., or H.M.E.) was considered as seemed applicable in arriving at Basic Loads for each specific station.

One specific factor tending towards the unconservative was as follows: Elliott utilized the daily water precipitation records of the Weather Bureau in his analysis of the December 1967 storm. Subsequent conversations with the Weather Bureau indicate that during heavy snow storms the amount of measured precipitation may be less than the actual precipitation, perhaps by 10 to 30%, due to losses in collecting and melting the snow. It is therefore quite possible that some of Elliott's loads were low.

However, on the conservative side, it seems much of the "hard" data, (obtained from Soil Conservation measurements and Elliott's report, and consisting of actual snow weights, not just depth measurements), represented something greater than a 30 year maximum.

The effects of the above factors were all estimated when arriving at Basic 30 Year Loads. No effort was made to err on either the conservative or unconservative side.

See also Conclusions at end of this report.

REDUCTIONS FOR WIND REMOVAL OF ROOF SNOW:

Wind can blow snow off roofs, and many codes make allowances for this. These allowances vary considerably however, between different geographical areas.

a. The Canadian code allows for snow blown off roofs by using a basic coefficient of 0.80. (Their roof load is assumed equal to 80% of the ground snow load.) Also allowed is an ultimate reduction down to 60% of ground snow if the roof is totally exposed to the wind on all sides.

b. Oregon allows approximately the same reductions as Canada, except in areas west of the Cascades where due to wetter snow and gentler winds further reduction to 60% is not allowed.

c. The California Division of Architecture allows no reduction for wind removal of roof snow. At one time they did allow a reduction down to 80% of the ground snow load, but extensive recent measurements seemed not to justify the reduction.

Unfortunately, there are no known available records of comparisons between roof and adjacent ground snow loads in Arizona, so experience in other areas must be utilized. In attempting to arrive at a recommendation for Arizona, the following items seemed pertinent:

a. Canadian winters are longer and colder than Arizona winters, giving more time for snow to be blown off Canadian roofs as well as colder, drier easier snow to blow off.

b. Canadian winter winds are generally stronger than Arizona winter winds.

c. Many of Arizona's maximum snow loads were recorded during the December 1967 storm of Elliott's report. This was a short period storm with little opportunity for blow off.

d. At many locations in Arizona (the lower elevations), maximum loads consist of wet sticky snow delivered during short period storms, with little chance for blow off. (Temperatures at these elevations tend to warm up and prevent long term build up between storms.)

REDUCTIONS FOR WIND REMOVAL OF ROOF SNOW (Continued)

The foregoing four points all argue against allowing as much wind reduction for Arizona as for Canada. However, not all Arizona snow is wet and sticky, and it would seem reasonable to allow reductions at higher altitudes in the colder parts of the State. Reductions equal to the Canadian wind reductions would seem reasonable at elevations above about 7,500 feet in the northern part of the State, (Zones I, II, III and IV). Reductions equal to say one half of the Canadian wind reductions would seem reasonable at elevations from about 6,000 feet to 7,500 feet in the north (Zones I, II, III and IV), and above about 7,000 feet in the south (Zone V).

In Zones I, II, III and IV, this would result in a Basic Roof Load equal to 80% of the Ground Snow Load at elevations above 7,500 feet, and equal to 90% of the Ground Snow Load between 6,000 feet and 7,500 feet. At Zone V Basic Roof Loads would be 90% of Ground Snow Loads at elevations above 7,000 feet. These values are listed in Tables 1 - 5. Also allowed would be further reductions for roofs fully exposed to wind on all sides, as explained in the Table footnotes.

None of the above reductions should be applied at lower elevations.

MODIFICATIONS DUE TO ROOF SLOPES, UNBALANCED LOADS, ROOF VALLEYS, MULTI LEVEL ROOFS, ROOF PROJECTIONS AND ICE LOADS:

The Canadian Building Code has recommendations for dealing with the above factors. Since Arizona conditions differ somewhat, as previously discussed under "Wind Removal of Roof Snow", the Canadian recommendations had to be modified to fit Arizona. Figs. C2-1 through C2-7 are patterned after the Canadian format as closely as possible. Coefficients are given to determine load patterns on the roof.

Caution!! As explained in Figs. C2-1 through C2-7, there are two types of coefficients, those with asterisks (C_s*), and those without asterisks (C). Coefficients C_s* are to be multiplied by the Basic Roof Snow Loads and coefficients C are to be multiplied by the Basic Ground Snow Loads in order to arrive at the adjusted roof loadings. (Basic Roof Loads given in Tables 1 - 5, including the further reductions for exposed buildings at higher elevations per footnotes in the Tables, are applicable to C_s*.)

a. Sloped Roofs: See Case I of Figs. C2-1, C2-2 and C2-3 for allowable reduqtions.

MODIFICATIONS DUE TO ROOF SLOPES, UNBALANCED LOADS, ROOF VALLEYS, MULTI LEVEL ROOFS, ROOF PROJECTIONS AND ICE LOADS (Continued)

b. Unbalanced Loads: Peaked and curved roofs produce an aerodynamic shade on the lee side. Snow from the windward side is blown over and dropped on the lee slope, building up an unbalanced load. See Case II at Figs. C2-2 and C2-3 for load distributions.

c. Roof Valleys: See Fig. C2-4 for load concentrations at roof valleys.

d. Multi Level Roofs: Lower roofs may build up snow which has either drifted or slid down from adjacent higher roofs. See Figs. C2-5 and C2-6 for load distributions.

e. Roof Projections: Snow may build up adjacent to roof projections. See Fig. C2-7 for distribution.

f. Ice Loads at Roof Edges: In addition to snow loads, ice loads should be applied at edges of sloped roofs. The following amounts appear reasonable for average conditions, but special conditions should receive special evaluation.

Basic Ground Snow Load (p.s.f.)	Ice Load Per Lin Ft at Lower Edge of Sloped Roof
20 - 30	50 p.l.f.
30 - 50	75 p.l.f.
Above 50	100 p.l.f.

GENERAL:

1. Skip Loading. All roof areas should have design snow load applied

   a. with full load on entire area or

   b. with full load on any portion of the area and zero load on the remainder,

whichever produces maximum stress on the member concerned. This is to guard against effects of partial snow removal, as well as recognizing the fact that snow loads are often uneven. This requirement applies to conditions shown in Figs. C2-1 through C2-7, as well as to all other snow loads.

GENERAL (Continued)

2. A distinction should be noted between say a normal 20 p.s.f. live load and a 20 p.s.f. snow load. The live load may be reduced according to roof slopes and tributary areas per building code allowances, whereas the 20 p.s.f. snow load is not subject to the same reductions.

3. Beware of rules of thumb for converting maximum snow depth into snow loads. New fallen snow at high cold areas can easily have only 5% water, while older snow may run up to 50% water. Water percentages are influenced by such factors as temperature of formation, temperature record on the ground, subsequent snowfalls, subsequent rain, depth of snow available to catch and refreeze melt or subsequent rain, clouds, sun, shade, weight pressing on the lower layers, etc.

4. Actual snow weight data (not just depths) will continue to be difficult to obtain at many areas. Observers are for the most part unpaid volunteers who have many other concerns, particularly during times of heavy storms, than the measurement of the water content of the snow on the roof.

5. Snow removal during heavy storms is unreliable. Streets impassable. Manpower blocked inside homes, etc. Designers cannot count on snow removal.

CONCLUSIONS:

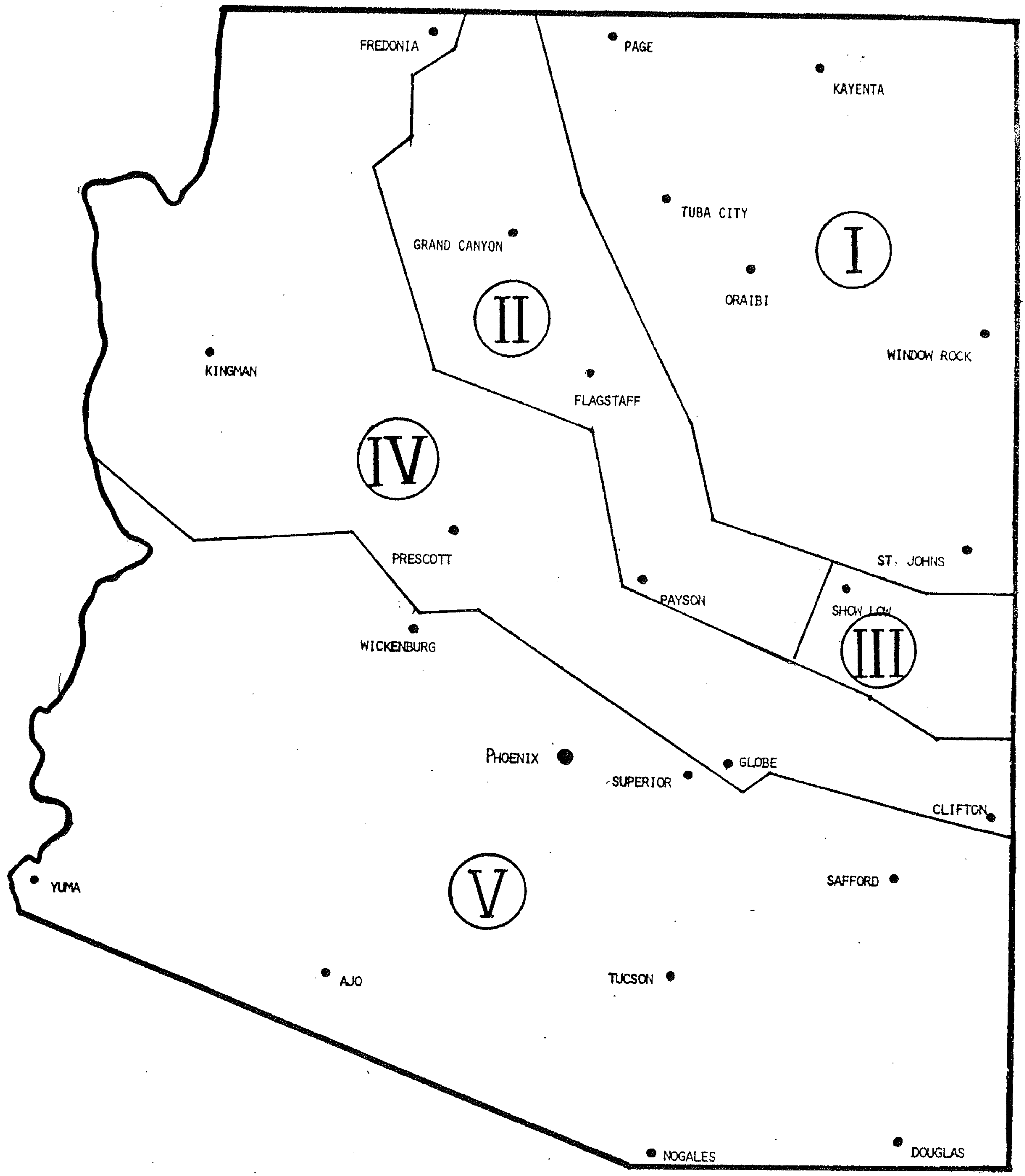
Until some future, more refined study is made, the Basic Snow Loads developed in this report seem to be a reasonable estimate of the maximum snow loads that might be expected over a 30 year period. As such, they could serve as a guide for design loads for structures. However, while as much information as possible was searched and reasonable care was used in the preparation of this report, there is obviously no way to guarantee that the loads listed will not be exceeded in the next 30 years. As stated earlier, no attempt was made to err on the conservative side. And no claim is made to Divine Revelation.

The listed values should be treated only as a guide. The designer must use his best judgment. Attention must be paid to local conditions that might cause increases; e.g. north slopes, shade, drifting, wind shelter that would prevent snow from blowing off roofs, etc., and particularly to any known history of heavier snow. And snow loads for structures requiring a high level of safety should always receive special consideration.

PREPARATION:

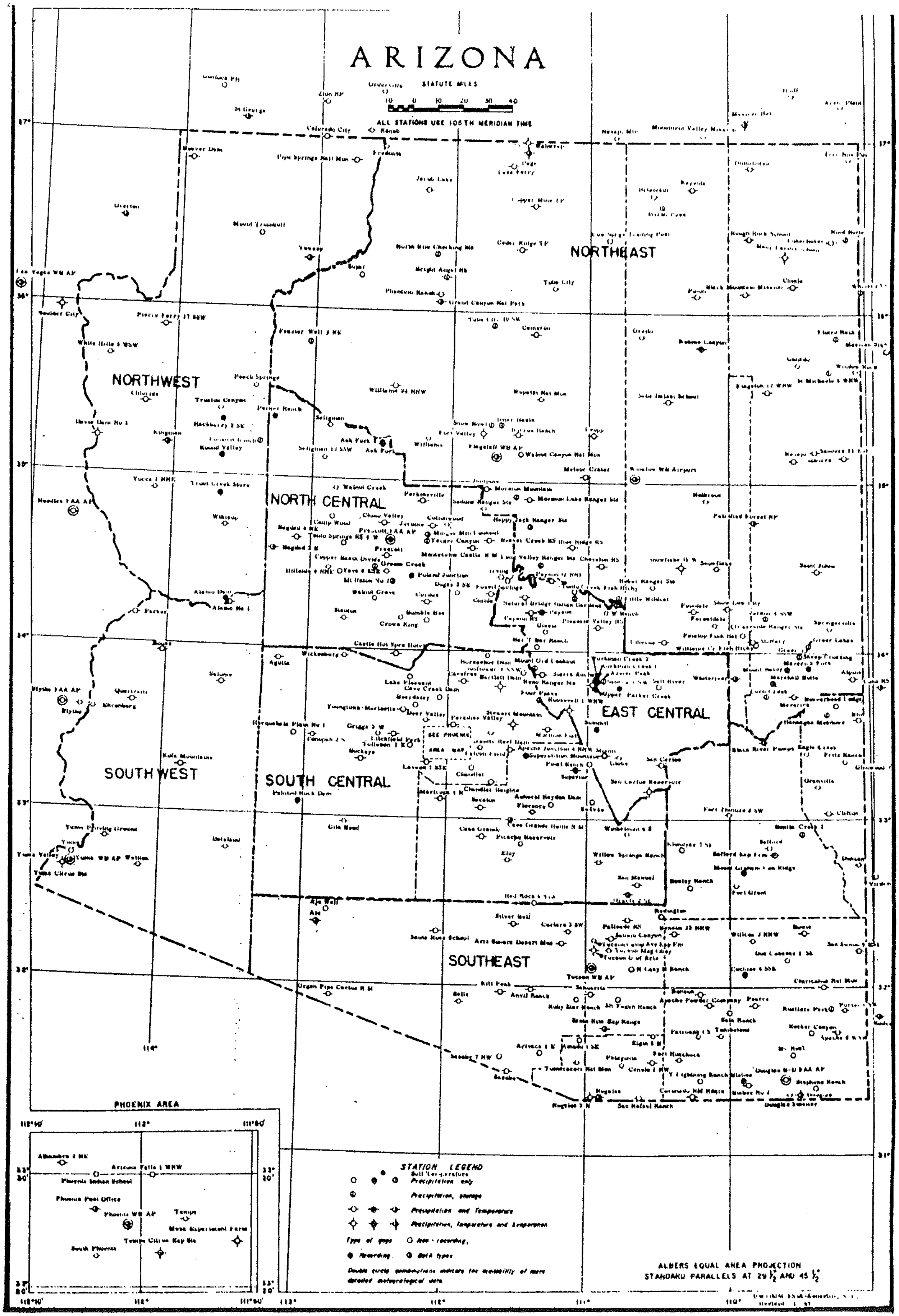
This report was prepared by a special Snow Load Committee of the Structural Engineers Association of Arizona, in cooperation with the Civil Engineering Department of Arizona State University. Much of the record search was done by John Nerison. Compilation and correlation of the data and preparation of the report was done under the direction of Mac Elliott.

After review by the board of directors of the Central Chapter of the S.E.A.A., and by other interested engineers, the report was circulated to building officials of the affected communities as well as to other pertinent government agencies, with requests for comments. Information received back generally correlated well with the report data. Where applicable, table values were adjusted slightly to reflect these comments, prior to publication.



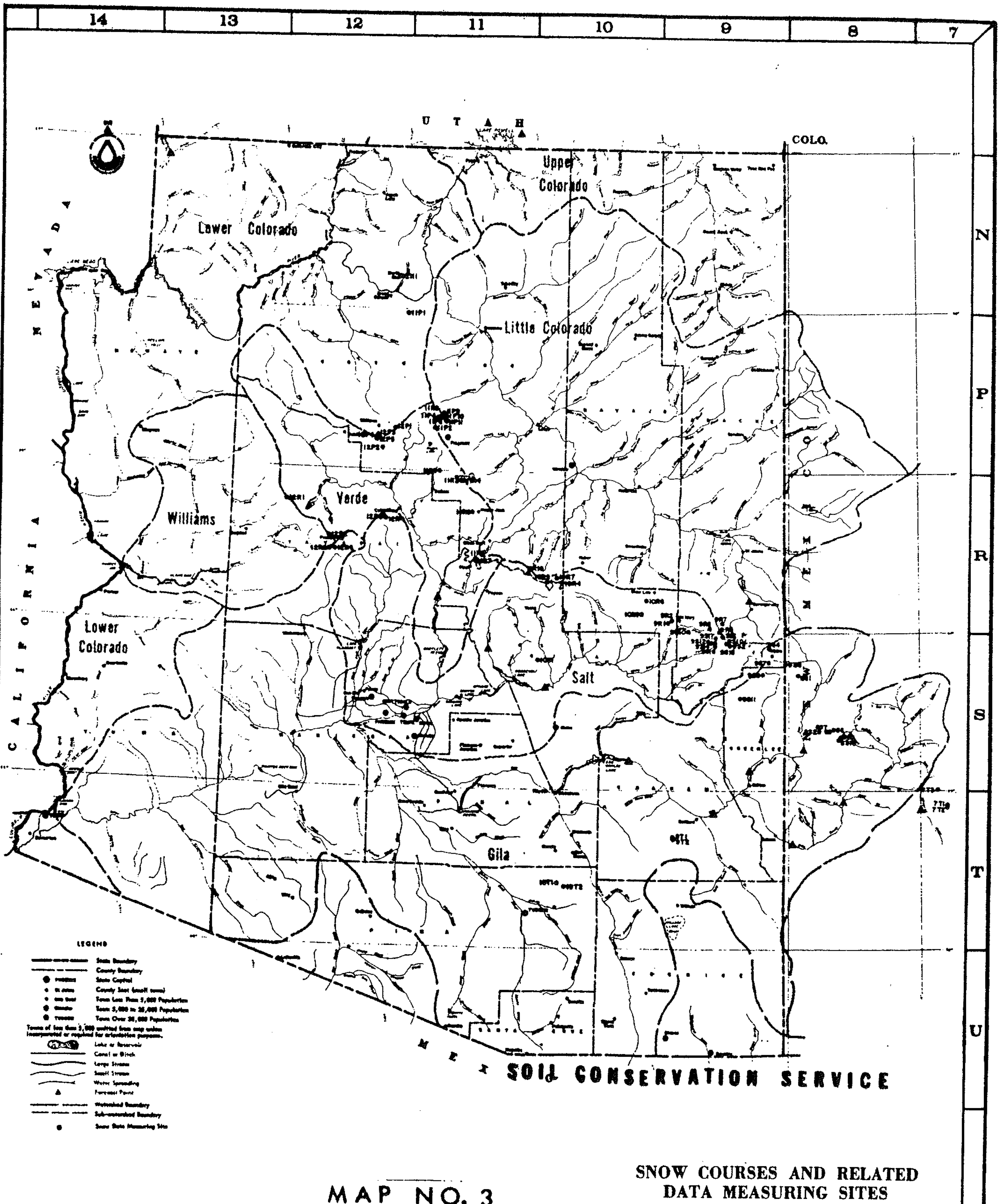
SNOW LOAD ZONES IN ARIZONA

MAP NO. 1



WEATHER BUREAU REPORTING STATIONS

MAP. NO 2



MAP NO. 3

SNOW COURSES AND RELATED DATA MEASURING SITES ARIZONA

1973

TABLE 1 SNOW ZONE I

Place	Elevation above Sea Level.	Month and Year of Maximum Snow.	Maximum Depth (inches)	Maximum Measured, Calculated, or Estimated Wt. of Snow on Ground (psf)	30 Year Basic Ground Snow Load (psf)	30 Year Basic Roof Snow Load (psf) **	Data Source †	Remarks
Betatakin	7286	12/67	38	10	20	18	HME	
Black Mountain Mission	6350	12/61	12	10*	20	18	WB	
Cameron	4165	12/67	18	8	12	12	HME	
Chinle	5538	12/67	11	9	16	16	HME	
Copper Mine T. P. (20 miles south of Page)	6380	12/60	23	16*	20	18	WB	
Dinnehotso	5020	12/67	--	8	16	16	HME	
Fort Defiance	6750	3/48	27.5	20*	20	18	WB	
Ganado	6350	12/67	24	10	20	18	HME	
Holbrook	5069	12/67	19	10	16	16	HME	
Jadito	6700	3/48	28	20*	20	18	WB	
Kaibato	6000	12/60	14	9*	20	18	WB	
Kayenta	5665	2/48	21	12*	16	16	WB	
Keams Canyon	6215	12/67	11	18	20	18	HME	
Leupp	4700	12/67	19	9	16	16	HME	
Lukachukai	6520	12/61	20	12*	20	18	WB	
Navajo (40 miles N.E. of Holbrook)	5580	12/67	—	8	16	16	HME	
Page	4270	12/67	9	7	12	12	HME	
Petrified Forest National Park	5460	11/31	20	12*	16	16	WB	
Pinon	6000	12/67	21	14	20	18	HME	
Saint Johns	5730	1/37	19	12*	16	16	WB	
Sanders 11 ESE	6250	12/67	20	8	20	18	HME	
Seba Dalkai School	5900	12/67	55	30*	25	25	WB	
Snowflake	5642	12/67	30	21	20	20	HME	
Tuba City	4936	12/67	20	7	16	16	HME	
Window Rock	6750	12/67	18	8	20	18	HME	
Winslow	4895	12/67	29	19	20	20	HME	
Wupatki National Monument	4908	12/67	32	13	16	16	HME	

† SCS = Soil Conservation Service. WB = Weather Bureau. HME = Elliott Report.

* Estimated weights (as opposed to measured or calculated weights).

** When roof is fully exposed to wind, 30 year Basic Roof Load may be further reduced 10% at elevations above 6000 ft., and 20% above 7500 ft. See Table 2 for example.

TABLE 2 SNOW ZONE II

	Elevation above Sea Level.	Month and Year of Maximum Snow	Maximum Depth (inches)	Maximum Measured, Calculated, or Estimated Wt. of Snow on Ground, (psf)	30 Year Basic Ground Snow Load (psf)	30 Year Basic Roof Snow Load (psf) **	Data Source †	Remarks
Agassiz (10 miles N. of Flagstaff)	11,200	4/73	126	220*	--	--	SCS	
Baker Butte (15 mi. North of Payson)	7,300	3/73	77	124	110	100	SCS	
Baker Butte #2 (15 mi. North of Payson)	7,700	3/73	97	160	145	115	SCS	
Bill Williams Intermediate (6 mi. So. Williams)	8,550	4/73	76	145	130	105	SCS	
Bill Williams Summit (6 mi. So. Williams)	8,950	3/73	108	164	150	120	SCS	
Bright Angel R.S. (No. Rim of Grand Canyon)	8,400	3/52	77	128	120	95	SCS	
Burrus Ranch (15 mi. N.E. of Flagstaff)	6,800	12/67	40	22	25	22	HME	
Canyon Creek #2 (13 mi. S.W. of Heber)	7,500	3/73	48	78	70	55	SCS	
Canyon Point (17 mi. S.W. of Heber)	7,600	3/73	59	90	80	65	SCS	
Chalender (7 mi. E. Williams)	7,100	3/73	44	62	55	50	SCS	
Chevelon R.S. (30 mi. N.E. of Payson)	7,006	12/67	52	39	50	45	HME	
Cibecue	4,950	12/67	16	31	30	30	HME	
Doyle Saddle (7 mi. No. of Flagstaff)	10,900	4/73	--	200*	--	--	SCS	
Flagstaff Airport	6,993	12/67	83	37	40	35	HME	May be light for some areas of city. e.g. see Fort Valley
Fort Valley (7 mi. No. of Flagstaff)	7,350	2/49	42	60	55	50	SCS	
Grand Canyon (10 mi. S.E. of Village.)	7,500	3/73	33	55	50	40	SCS	
Grand Canyon National Park	6,950	1/49	38	48*	45	40	WB	
Happy Jack (35 mi. So. of Flagstaff)	7,630	3/73	72	105	95	75	SCS	
Heber (12 mi. S.W. of Heber)	7,600	3/73	53	84	75	60	SCS	
Heber Ranger Station	6,590	12/67	48	44	40	36	HME	
Inner Basin #1 (10 miles North of Flagstaff)	10,000	4/73	125	228	205	165	SCS	
Inner Basin #2 (10 miles North of Flagstaff)	9,750	4/73	95	162	145	115	SCS	
Inner Basin #3 (10 miles North of Flagstaff)	10,250	4/73	--	240*	--	--	SCS	
Jacob Lake	7,920	4/73	60	85*	80	64	WB	
Mormon Lake (20 mi. So. of Flagstaff)	7,350	2/49	73	116	105	95	SCS	
Mormon Mountain (20 mi. So. of Flagstaff)	7,500	3/73	78	125	110	90	SCS	
Natural Bridge (10 mi. N.W. of Payson)	4,607	12/67	--	36	30	30	HME	
Newman Park (15 mi. S.W. of Flagstaff)	6,750	3/73	57	75	65	60	SCS	
Payson	4,913	12/67	48	47	40	40	HME	
Payson (12 mi. NNE)	5,500	12/67	42	55	50	50	HME	
Pleasant Valley R.S. (20 mi. E. of Payson)	5,050	12/67	27	26	25	25	HME	
Snow Bowl #1 (10 mi. No. of Flagstaff)	10,260	4/73	85	163*	--	--	SCS	
Snow Bowl #2 (10 mi. No. of Flagstaff)	11,000	4/73	130	222*	--	--	SCS	
Tonto Creek Fish Hatchery (15 mi. N.E. of Payson)	6,280	12/67	58	52	45	40	HME	
Walnut Canyon (10 mi. E. of Flagstaff)	6,685	12/67	54	43	40	36	HME	
White Horse Lake Junction (10 mi. So. of Williams)	7,180	3/73	57	86	75	70	SCS	
Williams	6,750	1/30	53	42*	40	36	WB	
Williams Ski Run (5 mi. So. of Williams)	7,720	4/73	70	128	115	105	SCS	
Young	5,200	2/44	25	20*	20	20	WB	

† SCS = Soil Conservation Service. WB = Weather Bureau.. HME = Elliott Report.

* Estimated weights, (as opposed to measured or calculated weights).

** When roof is fully exposed to wind, 30 year Basic Roof Load may be further reduced 10% at elevations above 6,000 ft., and 20% above 7,500 ft. e.g. Could reduce Flagstaff A.P. to 35 x .9 = 32 psf. Could reduce Bright Angel to 95 x .8 = 76 psf.

TABLE 3 SNOW ZONE III

Place	Elevation above Sea Level.	Month and Year of Maximum Snow	Maximum Depth (inches)	Maximum Measured, Caculated, or Estimated Wt. of Snow on Ground. (psf)	30 Year Basic Ground Snow Load (psf)	30 Year Basic Roof Snow Load (psf) **	Data Source †	Remarks
Alpine	8,020	12/67	60	36	50	40	HME	
Baldy (Sheep Crossing)	9,125	3/62	47	90	90	70	SCS	
Baldy #2 } 20 mi. SE	9,750	4/73	83	173	155	125	SCS	
Baldy #3 } of McNary	10,950	4/73	117	245	--	--	SCS	
Beaverhead Lodge (10 mi. S. of Alpine)	8,000	1/68	38	65	60	50	SCS	
Blue	5,760	12/67	42	36	35	35	HME	
Cheese Springs (18 mi. E. of McNary)	8,600	3/73	44	64	60	50	SCS	
Coronado Trail (4 mi. SW of Alpine)	8,000	2/49	38	64	60	50	SCS	
Forestdale (5 mi. SW of Show Low)	6,430	1/68	25	48	40	36	SCS	
Ft. Apache (17 mi. E. of McNary)	9,160	3/62	58	90	90	70	SCS	This is not the town of Ft. Apache.
Frisco Divide (15 mil. SE of Alpine)	8,000	1/68	31	50	50	40	SCS	
Greer	8,490	12/67	54	36	50	40	HME	
Hannagan Meadows	9,090	3/73	67	113	100	80	SCS	
Hawley Lake	8,300	12/67	91	57	95	75	HME	2 Sets Data Illustrate Different Wt/Depth Ratios
Hawley Lake	8,300	4/73	45	103	95	75	SCS	
Lakeside R.S.	6,700	12/67	52	36	40	36	HME	
Maverick Fork (20 mi. SE of McNary)	9,150	3/73	64	106	95	75	SCS	
McNary (2 mi. W. of McNary)	7,200	3/73	41	60	55	50	SCS	
McNary	7,320	1/37	71	60*	55	50	WB	
Milk Ranch (5 mi. SW of McNary)	7,000	3/73	32	42	45	40	SCS	
Mt. Ord (15 SE of McNary)	11,200	4/73	134	273*	--	--	SCS	
Nutrioso (3 mi. N. of Alpine)	8,500	2/49	34	47	50	40	SCS	
Pinedale (15 mi. W. of Showlow)	6,500	1/37	42	42*	40	36	WB	
Pinetop Fish Hatchery	7,200	12/67	54	52	50	45	HME	
Show Low	6,412	12/67	41	31	35	32	HME	
Smith Cienega (15 mi. SE of McNary)	10,050	3/73	97	191*	--	--	SCS	
Springerville	7,060	2/48	28	35*	35	32	WB	
State Line (7 mi. SE of Alpine)	8,000	1/68	33	42	50	40	SCS	
Sunrise Summit (17 mi. SE of McNary)	10,600	4/73	80	147	--	--	SCS	
Whiteriver	5,280	1/60	21	21*	25	25	WB	
Williams Creek Fish Hatchery (2 mi. SE of McNary)	6,960	1/49	52	55*	50	45	WB	
Wilson Lake (13 mi. E. of McNary)	9,000	3/73	73	112	100	80	SCS	

† SCS = Soil Conservation Service. WB = Weather Bureau. HME = Elliott Report.

* Estimated weights, (as opposed to measured or calculated weights).

** When roof is fully exposed to wind, 30 year Basic Roof Load may be further reduced 10% at elevations above 6,000 ft., and 20% above 7,500 ft. See Table 2 for example.

TABLE 4 SNOW ZONE IV

Place	Elevation above Sea Level.	Month and Year of Maximum Snow.	Maximum Depth (inches)	Maximum Measured, Calculated, or Estimated Wt. of Snow on Ground. (psf)	30 Year Basic Ground Snow Load (psf)	30 Year Basic Roof Snow Load (psf) **	Data Source †	Remarks
Ash Fork	5,200	12/67	38	14	20	20	HME	
Bagdad (8 mi. NE)	4,240	12/67	15	18	20	20	HME	
Beaver Creek R.S. (12 mi. S. of Sedona)	3,830	12/67	26	13	20	20	HME	
Call of the Canyon (10 mi. N. of Sedona)	5,329	2/44	60	48*	50	50	WB	
Camp Wood (30 mi. NW of Prescott)	5,700	2/49	33	45	40	40	SCS	
Chino Valley	4,750	12/67	22	16	20	20	HME	
Clifton	3,465	12/67	20	18	20	20	HME	
Copper Basin Divide (7 mi. SW of Prescott)	6,720	12/67	37	59	55	50	SCS	
Cordes Junction	3,773	12/67	15	23	20	20	HME	
Cottonwood	3,360	12/67	26	26	20	20	HME	
Crown King	6,000	12/67	54	60	55	50	HME	
Eagle Creek (20 mi. SW of Hannagan Meadows)	5,100	12/67	35	12	20	20	HME	
Fraziers Well 4 mi. NE (25 mi. NE Peach Springs)	6,500	2/44	22	30*	40	36	WB	
Fredonia	4,675	1/44	20	20*	20	20	WB	
Gaddes Canyon (20 mi. NE of Prescott)	7,600	3/73	72	108	100	90	SCS	
Globe	3,540	1/37	24	20*	20	20	WB	
Groom Creek	6,100	2/44	73	60*	50	45	WB	
Hilltop (55 mi. NE Peach Springs)	5,700	2/44	26	26	35	35	WB	
Highland Pines (7 mi. W. of Prescott)	7,000	12/67	48	52	55	50	HME	
Iron Springs (7 mi. W. of Prescott)	6,200	2/49	34	57	50	45	SCS	
Jerome	5,245	12/67	40	31*	30	30	HME	
Junipine (8 mi. N. of Sedona)	5,124	3/45	70	60*	50	50	WB	
Kingman	3,539	12/32	14	15*	20	20	WB	
Miami	3,560	12/67	16	21*	20	20	HME	
Mingus Mountain (20 mi. NE Prescott)	7,100	2/49	30	56	55	50	SCS	
Montezuma's Castle National Monument	3,180	12/67	19	16	20	20	HME	
Peach Springs	4,970	12/67	27	13	20	20	HME	
Pipe Springs National Monument	4,920	1/73	18	20*	20	20	WB	
Prescott	5,410	1/30	46	30	30	30	WB	
Sedona R.S.	4,223	12/67	15	18	20	20	HME	
Seligman	5,230	2/32	28	15*	20	20	HME	
Sierra Ancha (25 mi. N. of Miami)	5,100	12/67	30	47	40	40	HME	
Stanton (15 mi. N. of Wickenburg)	3,480	12/67	10	13	20	20	HME	
Tuweep (50 mi. SW of Jacob Lake)	4,775	12/41	17	17*	20	20	WB	
Walnut Creek R.S. (25 mi. SW of Ash Fork)	5,090	3/45	19	25*	20	20	WB	
Walnut Grove (16 mi. S. of Prescott)	3,764	2/44	25	25*	20	20	WB	
Workman Creek (30 mi. N. of Globe)	6,900	3/73	60	105	90	81	SCS	
Yaeger Canyon (10 mi. SW of Cottonwood)	6,000	1/45	30	30*	35	32	WB	
Yarnell	4,848	1/37	28	25*	25	25	WB	

† SCS = Soil Conservation Service. WB = Weather Bureau. HME = Elliott Report.

* Estimated weights, (as opposed to measured or calculated weights).

** When roof is fully exposed to wind, 30 year Basic Roof Load may be further reduced 10% at elevations above 6,000 ft., and 20% above 7,500 ft. See Table 2 for example.

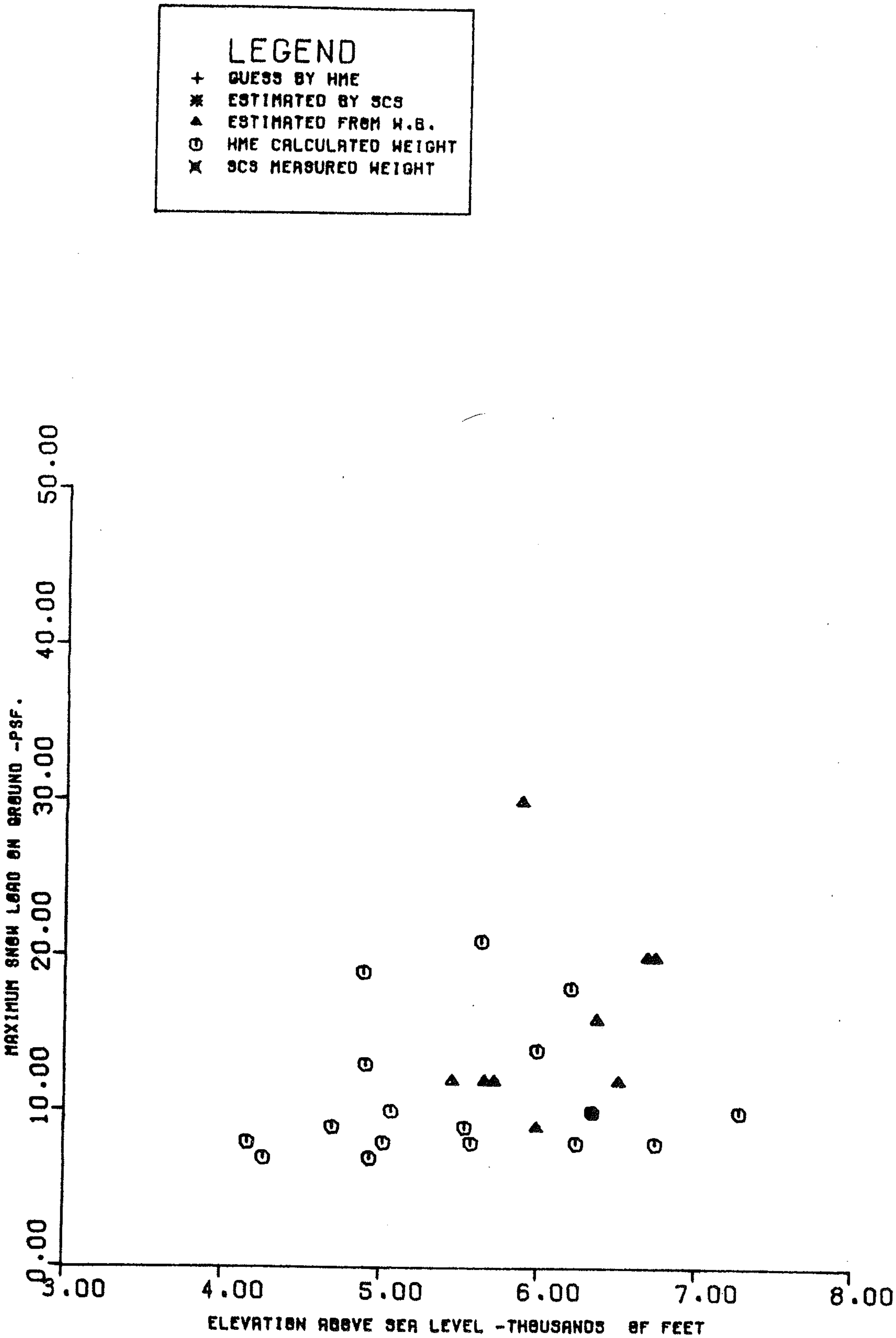
TABLE 5 SNOW ZONE V

Place	Elevation above Sea Level.	Month and Year of Maximum Snow.	Maximum Depth (inches)	Maximum Measured, Calculated or Estimated Wt. of Snow on Ground. (psf)	30 Year Basic Ground Snow Load (psf)	30 Year Basic Roof Snow Load (psf) **	Data Source †	Remarks
Bear Wallow (20 mi. NE of Tucson)	8,100	2/68	40	88	88	79	SCS	
Bisbee	5,440	12/67	24	17	20	20	HME	
Bisbee #2 (3 mi. SE of Bisbee)	5,020	1/49	20	10*	20	20	WB	
Chiricahua National Monument	5,300	12/67	28	16	20	20	HME	
Crazy Horse (14 mi. SW of Safford)	10,200	3/66	108	198*	--	--	SCS	
Dos Cabezas (15 mi. SE of Willcox)	5,100	12/67	12	16	20	20	HME	
Douglas	4,040	12/67	--	5	12	12	HME	
Ft. Grant	4,875	12/67	10	13	20	20	HME	
Ft. Huachuca	4,664	12/67	7	13	20	20	HME	
High Peak (14 mi. SW of Safford)	10,500	3/66	120	218*	--	--	SCS	
Kitt Peak	6,875	12/67	35	44	44	44	HME	
Nogales	3,800	12/71	--	10	12	12	HME	
Oracle 2 mi. SE	4,540	1/37	26	21*	20	20	WB	
Palisade R.S. - Mount Lemmon	7,945	2/66	86	86*	80	72	WB	
Patagonia	4,044	12/67	--	8*	12	12	HME	
Pearce (20 mi. NE of Tombstone)	4,420	12/67	4	5	12	12	HME	
Pinal Ranch (5 mi. E. of Superior)	4,520	12/67	25	26*	20	20	HME	
Portal 4 mi. SW	5,390	12/67	31	26	20	20	HME	
Rose Canyon (20 mi. NE of Tucson)	7,300	2/66	53	71	70	63	SCS	
Sala Ranch (10 mi. NE of Tombstone)	5,190	12/67	11	10	20	20	HME	
Safford	2,900	12/67	14	10	12	12	HME	
San Manuel	3,560	12/67	5	10	12	12	HME	
Santa Rita Experimental Range (25 mi. S. of Tucson)	4,300	12/67	--	10	12	12	HME	
Tombstone	4,540	12/67	--	10*	20	20	HME	
Willcox 3 mi. NNW	4,190	12/67	6	8	12	12	HME	

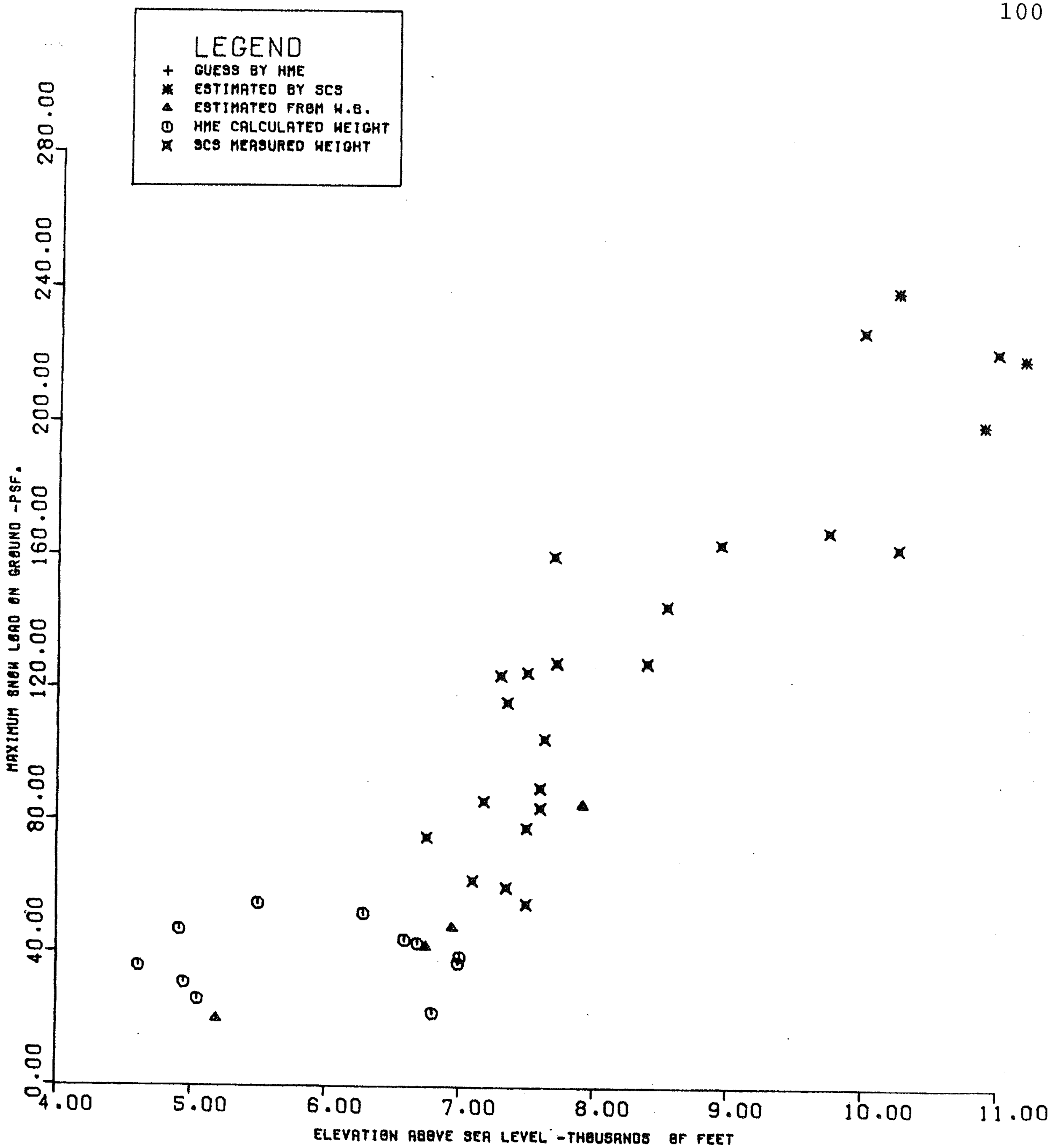
† SCS = Soil Conservation Service. WB = Weather Bureau. HME = Elliott Report.

* Estimated weights, (as opposed to measured or calculated weights).

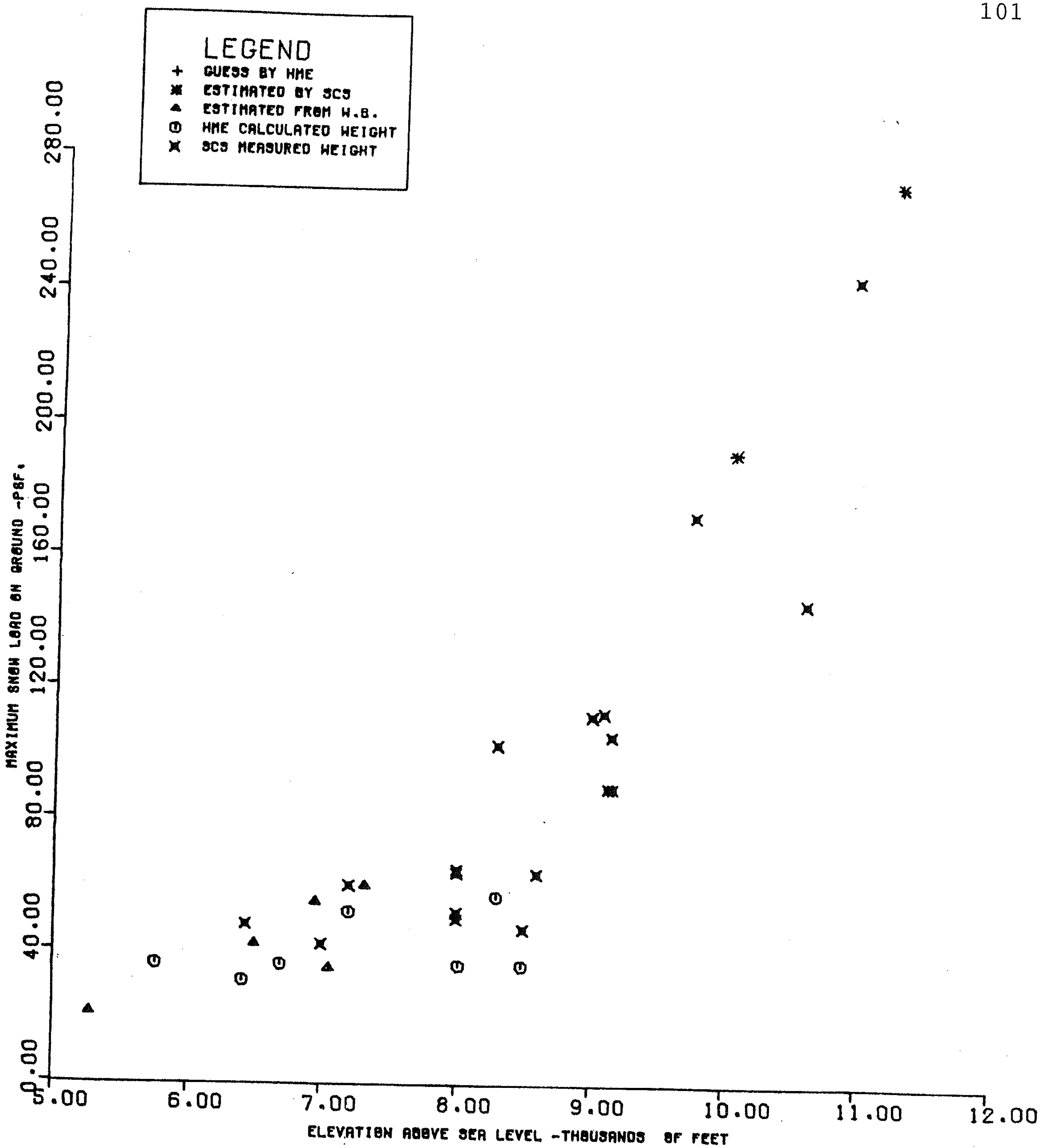
** When roof is fully exposed to wind, 30 year Basic Roof Load may be further reduced 10% at elevations above 7,000 ft. See Table 2 for example.



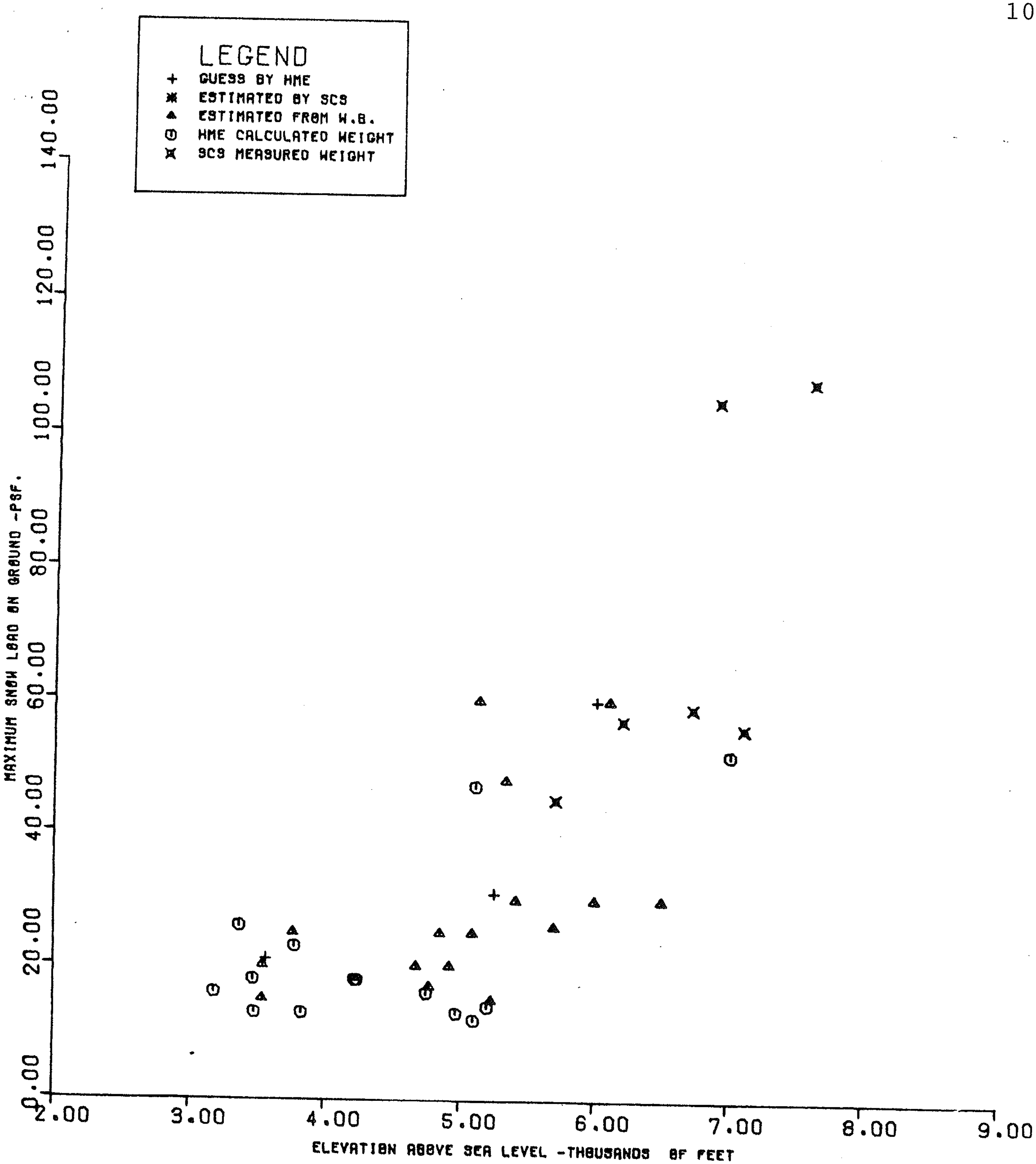
MAXIMUM GROUND SNOW LOADS VS ELEVATIONS-ZONE I
FIGURE 1



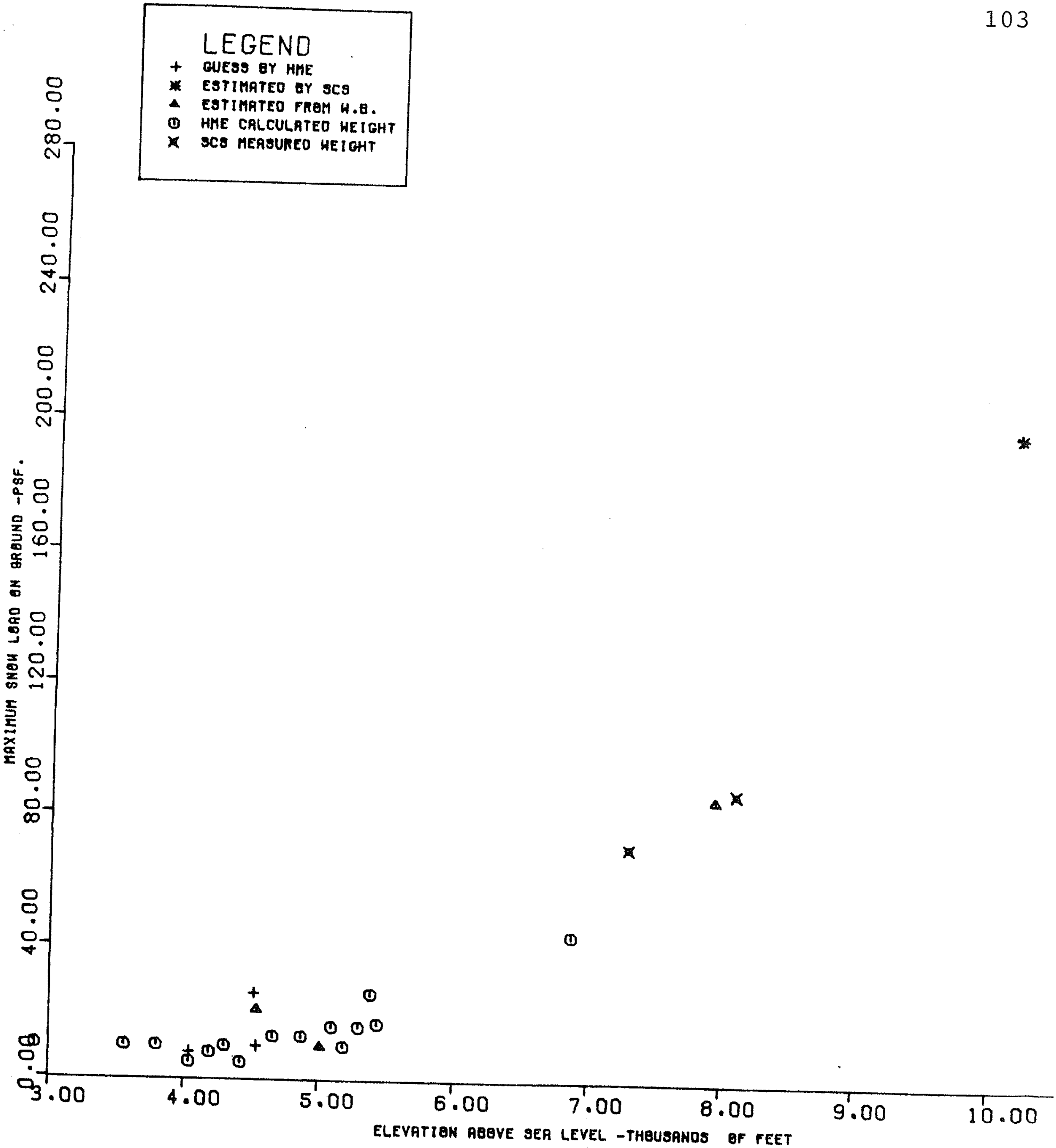
MAXIMUM GROUND SNOW LOADS VS ELEVATIONS-ZONE II
FIGURE 2



MAXIMUM GROUND SNOW LOADS VS ELEVATIONS-ZONE III
FIGURE 3

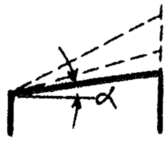


MAXIMUM GROUND SNOW LOADS VS ELEVATIONS-ZONE IV
FIGURE 4

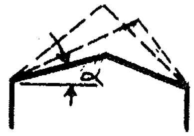


MAXIMUM GROUND SNOW LOADS VS ELEVATIONS-ZONE V
FIGURE 5

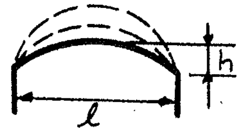
ROOF SHAPES



Simple flat & shed roofs



Simple gable & hip roofs



Simple arch & curved roofs.

SNOW LOAD DISTRIBUTIONS & COEFFICIENTS

Fig C2-1 — Flat & Shed Roofs

Case I

C_s^*

$C_s^* = 1.0 - \frac{\alpha - 30}{50}$

Typical Values

α	C_s^*
0 to 30°	1.0
40°	0.8
50°	0.6
60°	0.4
70°	0.2
80 to 90°	0

Fig C2-2 — Gable or Hip Roofs

Case I

C_s^*

Case II

C_s^*

for $\alpha \leq 20°$ Use Case I

for $\alpha > 20°$ use Case I & Case II

Case I

$C_s^* = 1.0 - \frac{\alpha - 30}{50}$

Case II

$C_s^* = 1.25(1.0 - \frac{\alpha - 30}{50})$

Fig C2-3 — Arch Roofs

Case I

$C_s^* = 1.0$

Case II

$C = 2.0$

for $\frac{h}{\ell} \leq \frac{1}{10}$ use Case I

for $\frac{h}{\ell} > \frac{1}{10}$ use Case I & Case II

Fig C2-1
Flat & Shed Roofs

Fig C2-2
Gable or Hip Roofs

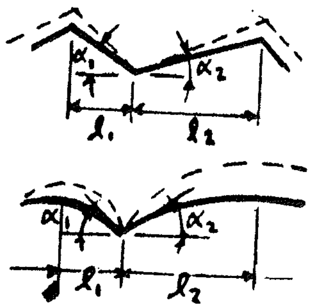
Fig C2-3
Arch Roofs

Notes:

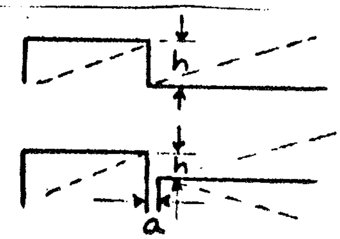
1. In Figs C2-1 & C2-2 the term $\frac{\alpha - 30}{50}$ is only valid for slopes greater than 30°.
2. C_s^* = coefficient to be applied to Basic Roof Snow Load.
3. C = coefficient to be applied to Basic Ground Snow Load.

MODIFICATIONS DUE TO ROOF SLOPES AND UNBALANCED LOADS

ROOF SHAPES



Valley Areas of 2-span & multi span sloped or curved roofs



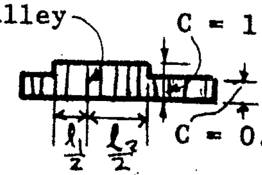
Lower level of multi-level roofs (where upper roof is part of the same building or on an adjacent building not more than 15 ft. away.)

SNOW LOAD DISTRIBUTIONS & COEFFICIENTS

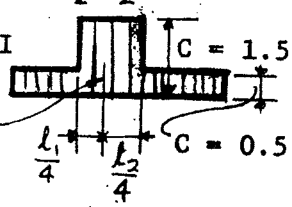
Case I  C_s^* (uniform load)

$$C_s^* = 1.0 - \frac{\alpha - 30}{50}$$

Case II

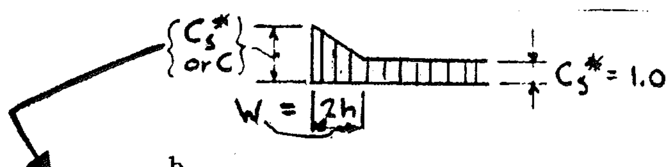


Case III



$$\beta = \frac{\alpha_1 + \alpha_2}{2}$$

for $\beta \leq 10°$ use Case I
for $10° < \beta < 20°$ Use Case I & II
for $\beta \geq 20°$ use Case I, II & III



$C = 15\frac{h}{g}$ except:

when $15\frac{h}{g} \leq 1.0$, use $C_s^* = 1.0$

when $15\frac{h}{g} > 3.0$, use $C = 3.0$

W = 2h except:

when h < 5ft use W = 10
when h > 15ft use W = 30

h = difference of roof heights in ft.
g = Basic Ground Snow Load in psf
w = width of drift from higher bldg. in ft.
a = distance between bldgs. < 15ft.

For loads on upper roof use Figs. C2-1 to C2-4.

Fig. C2-4
Valley Areas of 2-span & Multi Span Sloped or Curved Roofs.

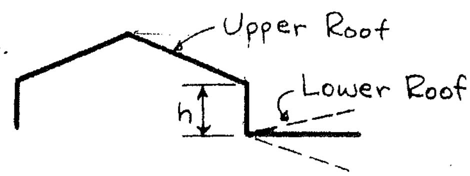
Fig C2-5
Lower Roof of Multi-Level Roofs.

Notes:

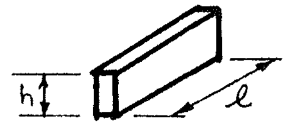
1. In Fig C2-4 the term $\frac{\alpha - 30}{50}$ is only valid for slopes greater tahn 30°.
2. C_s^* = coefficient to be applied to Basic Roof Snow Load.
3. C = coefficient to be applied to Basic Ground Snow Load.

MODIFICATIONS DUE TO ROOF VALLEYS AND MULTI LEVEL ROOFS.

ROOF SHAPES



Lower of multi-level roofs with upper roof sloped towards lower roof.

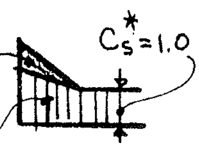


Roof areas adjacent to projections & obstructions on roofs.

SNOW LOAD DISTRIBUTIONS & COEFFICIENTS

W_1 = Total load from sliding snow

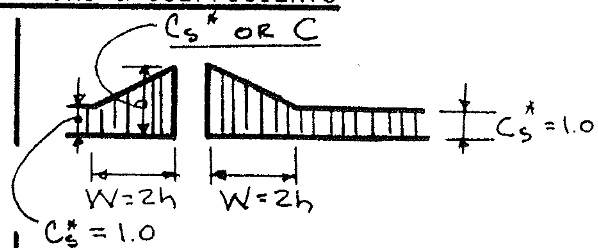
Drift load per Fig C2-5



Design lower roof for loads according to Fig. C2-5, plus W_1.

(Designer must use judgement in estimating W_1, the maximum probable weight of snow melt or sliding snow from roof above. As a guide only, for average conditions, W_1 could equal 50% of the maximum total design load on the portion of the upper roof which slopes towards the lower roof.)

Design upper roof for loads according to Figs. C2-1 to C2-4.



$C = 10\frac{h}{g}$ except:

when $10\frac{h}{g} < 1.0$, use $C_s^* = 1.0$

when $10\frac{h}{g} > 2.0$, use $C = 2.0$

when $\ell < \frac{g}{6}$ use $C_s^* = 1.0$

W = 2h except:
when h < 5ft use W = 10
when h > 15ft use W = 30

h = height of projection in ft.
g = Basic Ground Snow Load in psf
w = width of snow drift in ft.
ℓ = length of projection in ft.

Fig C2-6
Lower Of Multi-Level Roofs With Upper Roof Sloped Towards Lower Roof.

Fig C2-7
Areas Adjacent To Roof Projections.

Notes

1. C_s^* = coefficient to be applied to Basic Roof Snow Load.
2. C = coefficient to be applied to Basic Ground Snow Load.

MODIFICATIONS DUE TO MULTI LEVEL ROOFS & ROOF PROJECTIONS.

BIBLIOGRAPHY:

1. Snow Survey Measurements for Arizona
   U. S. Department of Agriculture - Soil Conservation Service

2. Climatological Data for Arizona
   U. S. Department of Commerce - Weather Bureau

3. Actual Snow Loads in Arizona
   Storm of December 13 - 20, 1967 - H. M. Elliott

4. Snow Load Design Data for Colorado
   Structural Engineers Association of Colorado - 1971

5. Snow Load Analysis for Oregon
   Structural Engineers Association of Oregon - 1971

6. Snow Loads and Roof Failures
   John F. Meehan
   Paper presented at Structural Engineers Association of California Annual Convention - 1969

7. National Building Code of Canada 1970
   Supplement No. 4, Commentary No. 2, Snow Loads